Inspiring Climate Action Now

Science as a Foundational Skill:

Building Essential Habits of Mind for a Climate-Adaptive Future

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Science as an Integrative Foundational Skill

Globally, investment in foundational skills has increased notably over the past two decades, as countries and their development partners have recognized the gaps between aspirations to educate all children and the realities of what many of those children experience and learn in school.

Learning poverty levels remain staggeringly high,[1] but efforts to support evidence-based instruction in literacy, mathematics, and social and emotional learning (SEL) have begun to close the gap that yawns between those who succeed and those who do not.[2] Fundamental questions of equity related to who acquires literacy and numeracy, when they acquire those skills, and how they negotiate the social and emotional challenges of life in resource-limited contexts remain, but there is broad agreement on the importance of investment in foundational skills and a commitment to doing so.

Literacy skills are an essential gateway to understanding, expression, and advocacy. The mechanics of reading and writing unlock opportunities for meaning-making, and literacy is a powerful tool for thinking. Fluent readers and writers are able to use written language to benefit themselves and their communities. Similarly, mathematics skills enable people to access, understand, interpret, and manipulate information that has immediate import to their lives, and to make better sense of the way the world works around them. Social-emotional skills promote sustained success in work and life, as well as better social integration, self-efficacy, and communication.

However, these three sets of skills remain largely divorced from one another in the primary education systems of many countries, and they are taught at a very basic level. The mechanics of reading and writing, the foundations of mathematical operations, and the basics of self-management and group relationships are typically taught separately, and they often do not build to their ultimate goal: the making of meaning and the taking of action to better one's life, one's community, and the world. Those purposes remain the domain of upper primary school, at best, or of higher levels of education from which many young people are excluded.

Science education bridges the gaps between these foundational skill sets and enables them to be used to greater effect, even in the early primary years.[4] Primary science allows children to operationalize and use their literacy and numeracy skills and engage their social-emotional resources, developing the strong foundation of critical thinking, problem-solving, and decision-making that is so essential to later success.[5]

Table 1. Essential Science Practices[3]

Investigating Practices	Sensemaking Practices	Critiquing Practices
Asking questions	Developing and using models	Engaging in argument from evidence
Planning and carrying out investigations	Analyzing and interpreting data	Obtaining, evaluating, and communicating information
Using mathematical and computational thinking	Constructing explanations	

1 World Bank, 2022
2 Akyeampong et al., 2023
3 McNeill et al., 2015; Van Uum et al., 2016;
4 National Research Council, 2012
5 National Research Council, 2012

In short, science skills and habits of mind are the missing element of the foundational skills package, and their addition to the mix can accelerate education recovery and reform.

In the context of climate change, these skills are even more critical.

Science thinking and science practices promote the adaptation and resilience that the world will need to respond effectively to the challenges posed by rising sea levels; changes in weather; and the health, economic, and stability risks that are associated with alterations in the climate, both locally and globally.[6] Beginning early, building on local assets, and developing science skills and science thinking in *all children* can help to ensure that those most marginalized by climate change are not left out, and that they both benefit from and contribute to the transformations that will need to take place.

Science practices and habits of mind (***Table 1***) reinforce the goals of literacy, mathematics, and SEL instruction. Studies have shown that children learn more in all subjects when teachers pair inquiry-based science with literacy and mathematics in authentic ways.[7] Interdisciplinary learning based on inquiry offers learners more relevant, more stimulating, and less disjointed learning experiences.[8] Integrating the foundational disciplines also more closely resembles the interdisciplinary nature of work, enabling learners to develop the ability and confidence to think and work in a cross-cutting way.

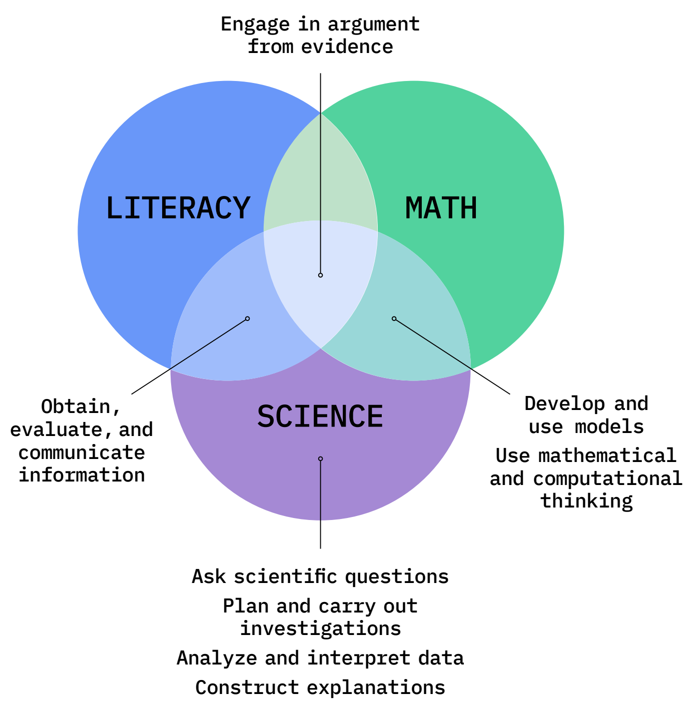
Science is a fundamentally integrative activity that reinforces all foundational skill sets. As shown in ***Figure 1***, the science practice of obtaining, evaluating, and communicating information is also a critical literacy practice. The science practices of developing and using models and using mathematics and computational thinking are also mathematical practices. The practice of engaging in argument from evidence is an ability that is central to all three disciplines, as well as to others both within and beyond schooling.

Science and Literacy

Learning science by *doing* science is inherently exciting and engaging. When children are motivated and engaged, they work harder with written text, even when it is challenging. They read more, understand more, write better, and learn faster. When learners read text on a topic they find interesting, they employ comprehension processes more frequently, use a greater variety of comprehension processes, and have greater recall.

Scientific work includes reading, writing, and other literacy practices, as well as critiquing practices (engaging in an argument from evidence and obtaining, evaluating, and communicating information). By teaching literacy in the context of science, learners make greater gains in literacy practices, learn more science, *and* experience the relevance of literacy to science.

Figure 1: Science, Math, and Literacy Connections



6 UNESCO & MECCE, 2024; Sabarwal et al., 2024
7 Frykholm & Glasson, 2005; Furner & Kumar, 2007; Minner et al., 2010
8 Marshall et al., 2017

Science and Mathematics

Science provides learners with concrete examples of abstract mathematical ideas, while mathematics enables learners to achieve deeper understanding of science concepts by providing ways to quantify and explain science relationships.[9]

Opportunities for exercising the practices of mathematics in the course of science investigations or vice versa abound. In the simplest sense, when learners design and conduct an investigation, they are necessarily collecting data, counting, and measuring; graphing, modeling, or creating other visual presentations of data; conducting analysis by making comparisons, looking for patterns, and understanding relationships; and communicating and explaining investigation processes and findings. All these activities call upon the use of mathematical process skills, computation, and literacy skills.

Science and Social and Emotional Learning

The critical habits of mind that foundational science instruction seeks to develop in learners (*Table 2*) are, at their root, social-emotional skills. Strengthening learners' capacity in these areas carries over into other applications beyond science, enhancing thinking, meaning-making, relationship-building between individuals, and the location of self in society.[10]

Development of the core science practices and habits of mind begins very early in life, and can be accomplished in the earliest stages of education. Young children are fundamentally curious. They are fascinated by the world around them and are intrinsically motivated to learn and understand how it works. Before they enter school, they have discovered for themselves many key concepts in science, particularly in physics and biology. Tapping into that fascination and capitalizing on it as children mature are key to keeping them actively engaged in learning.[11]

Foundational science practices can be easily adapted for young learners and used to reinforce the

> "Teachers who instill the importance of protecting clean air, water and soil, and the threats against them are investing in developing a generation of children who could potentially be our climate solvers rather than our climate victims...By coming together to encourage our young people to understand science firsthand we are making a powerful investment toward climate solutions."[12]

Table 2: Core Habits of Mind in Inquiry-Based Science

Curiosity	Critical thinking	Creativity
Openness to new ideas	Responsibility and self-direction	Humor
Flexibility	Metacognition	Perseverance

9 McBride & Silverman, 1991
10 Kagawa & Selby, 2022; Ojala, 2023
11 Herpratiwi & Tohir, 2022; Sheldrake et al., 2017
12 Cerezo, 2022

development of other foundational skills, as the three common science practices for pre-primary to grade 2 illustrate, as seen in ***Figure 3*** (drawn from the Next Generation Science Standards[13]).

Primary Science for Educational and Occupational Equity

Access to foundational primary science education is also an equity issue. All learners deserve to experience science and develop related skills and habits of mind, no matter who they are, where they live, what grade they are in, or how well they perform in other subjects. Indeed, placing a high value on showcasing the relevance of science to learners' lives in their earliest years lays the groundwork for continued engagement in science learning, full and informed participation as citizens, and the pursuit of science careers later in life.[14] Learners' belief in the value of science is a strong and positive predictor of their science-related career interests;[15] cultivating that belief in the foundational years of primary school is the key to a door of opportunity.

Careers in STEM (science, technology, engineering, and math) and employment opportunities in the blue and green economies are increasing, but they are often limited to those who are able to access secondary and tertiary education in which science is taught. In lower- and middle-income countries, the narrowing of the educational pyramid after primary school means that, for many children, and particularly for those from marginalized communities, these opportunities are lost. Many children in low- and middle-income countries (LMICs)—and the marginalized, in particular—are excluded. Gender, poverty, disability, rural isolation, and language skills prevent many learners from moving on to higher levels of education, thereby filling science professions with those who lack understanding of and connections to those most in need of the changes that science can power and support.[16]

Many education systems struggle with limited resources and large classrooms in the primary grades, and policymakers and educators alike believe that science cannot be taught effectively under these conditions.

Figure 3: Science Practice Progressions, Grades Pre-Primary (K) to 2

Planning and Carrying Out Investigations

1. With guidance, plan and conduct an investigation in collaboration with peers.(P)
2. Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.
3. Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.

Using Mathematical and Computational Thinking

1. Use counting and numbers to identify and describe patterns in the natural and designed worlds
2. Describe, measure, and/or compare quantitative attributes of different objects, and display the data using simple graphs.

Obtaining, Evaluating, and Communicating Information

1. Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed worlds.
2. Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.
3. Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide details about scientific ideas, practices, and/or design ideas.

13 Next Generation Science Standards, 2013
14 Aditomo & Klieme, 2020; Kember et al., 2008; Rubiano-Matulevich et al., 2019
15 Areepattamannil et al., 2020; Sheldrake et al., 2017
16 Avolio et al., 2020

Investigation, in particular, is often relegated to higher grades, where learners can read and follow instructions, and resources for activities can be provided at more limited scale. Primary teachers do not always see science as something that young learners are capable of doing, and those in the most marginalized communities may not believe that careers in science are within their learners' reach. But inquiry skills and practices are not limited to experimentation in structured science laboratories—indeed, they can be fostered at very low cost in almost any context. **Primary science can indeed be taught well in large classrooms, to children who are not yet literate, by teachers who are not science specialists.** It is a crucial element of systemic equity to ensure that schools do so.

Leading with the relevance of science ideas and concepts to learners' lives is critical to ensuring learners' investment in their own learning.[17] Understanding the water cycle, for instance, in the context of the weather that learners, their families, and communities experience, is quite different from learning generic facts. Key to showcasing the relevance of particular science concepts is making them concrete, observable, and accessible to learners. Picking the "right" phenomenon for learners to engage with creates the opportunity for learners to connect personally with the content. It engages their curiosity, and their questions about their observations quickly emerge—the first step in constructing authentic, relevant, and meaningful investigations. Once science as *learning facts* is supplanted with *drawing facts from observation*, children become capable of independently making connections as opposed to simply consuming ideas that may be outdated or, worse, incorrect.[18]

Investment in primary science education builds on countries' long-term investments in literacy and math, and it supports cross-curricular skill building by practicing science to engage with the language skills of reading, listening, and speaking, and with mathematical concepts such as number sense, calculations, patterns, relationships, and analysis of change. Primary science in a low-cost, inquiry-focused mode completes the

foundational skills puzzle for learners, ensuring that not only do they master the mechanics of literacy and numeracy, they also have the habits of mind and hand to put those skills to use for themselves and for their communities. The skills and practices learned in the science classroom build an equitable foundation to help all youth succeed.

Climate Education as a Focus of Primary Science

In the context of climate change, early understanding and application of science skills and habits of mind are particularly crucial.[19] The core inquiry skills of critical thinking, collaboration, complex problem-solving, judgment, and cognitive flexibility are essential to addressing climate challenges.[20] These skills enable people to ask important questions, consider and make sense of data, look at conflicting findings in new ways, invent novel approaches, and sharpen evolving understandings—all essential for ensuring the well-being of individuals, communities, and societies in a changing world. And they can be developed from the very earliest educational experiences before children even learn to read. Individual and systemic resilience and adaptation to climate change can—and should—be supported through practical, meaningful science education at the foundational levels of the system.

17 Babaci-Wilhite, 2017
18 Abd-el-Khalick et al., 2004; Ajitomi & Gbadamosi, 2015
19 Simpson et al., 2021, Monroe et al., 2019
20 Lehtonen et al., 2019; Kwauk & Casey, 2021

Introducing climate education in the early grades also prevents it from remaining the purview solely of scientists and policymakers, disconnected from the daily life of citizens. Locally driven solutions will be needed to balance national and global investments, but if people are not encouraged to take notice of and empowered to respond to the climate challenges they and their communities are experiencing, solutions will continue to be divorced from those most affected by climate change.[21] Preparing children and the adults in their orbit to participate in learning about climate science and addressing climate change is an investment in finding solutions for their future.[22]

Climate-focused primary science education engages learners, educators, and communities in issues that are directly relevant to them and meaningful in their everyday lives, making the integration of science education in primary schooling more appealing and more meaningful.[23] It is never too early to provide learners with the skills to analyze and act on the world around them—skills that can be put to use almost immediately by linking science learning with practice.[24] As young children are among the populations most vulnerable to climate change, efforts to adapt systems to reduce risk and increase resilience must include them both as beneficiaries and as active participants in learning to respond to climate challenges.

Primary-level science education can support a broad understanding of and resilient responses to climate and environmental changes and the development of empowered climate-adapted citizens.[25] Although these foundational skills are not currently emphasized in many education systems in LMICs, they represent a gap that urgently needs to be filled.

Global Levers for Primary Science Integration

At the global level, integration of primary science within the foundational skills framework will require several essential steps. Governments and development partners will need to align their science investments with those already underway in literacy, numeracy, and SEL, based on common principles and evidence-based practices.

STEP 1:

Shared understanding of inquiry-based science teaching and the opportunities and challenges of its implementation in primary classrooms in LMICs

A common understanding of the nature, purpose, and results of inquiry-based science education will support effective integration of primary science in LMICs. Although developed in the United States, the Next Generation Science Standards (NGSS)[26] were internationally benchmarked and have inspired science reforms in multiple non-U.S. contexts, and can thus serve as a potential foundation for this conversation. The NGSS are adaptable to a wide range of implementation contexts, and they engage with and uphold the importance of local knowledge, language, and cultural fit in science instruction. The NGSS capture the essential knowledge, skills, and habits of mind developed through inquiry-based science instruction, and enlist learners, educators, parents and caregivers, communities, researchers, and business and industry as partners in learning. Conversations around the principles and practices outlined in the NGSS can be used to better understand the ways in which they can be integrated into LMIC education systems, and aligned with existing efforts to improve literacy, numeracy, and SEL. Conversations at the cross-national level that include development partners and draw on LMIC-focused research on inquiry-based science can help ensure that interventions coalesce around and address a common set of challenges, while also harnessing assets and opportunities that are both cross-cutting and localized to LMICs. Long-term consideration of science as a subset of skills within the Global Proficiency Framework may support better integration and comparison across contexts.

21 Asad et al., 2023; Benevolenza & DeRigne, 2019
22 Bangay, 2022; O'Neill et al., 2020
23 Karpudewan et al., 2015; Bos & Schwartz, 2023
24 UNESCO, 2024
25 Promising data on locally led climate change-centering science instruction in primary grades is emerging, for instance, from the Inspiring Climate Action Now (ICAN) demonstration programs in Mali, Zambia, and Antigua & Barbuda. Insert link to ICAN webpage here, please.
26 Next Generation Science Standards, 2013

STEP 2:

Clarification of how the components of education systems must be re-aligned to enable teachers to successfully implement inquiry-based primary science education

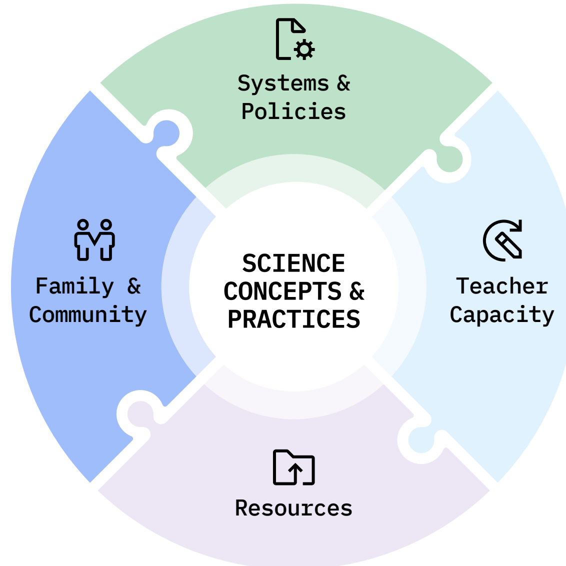
Some national education systems in LMICs already aspire to integrate the NGSS principles and practices into their existing programming, and some have had more success than others at adjusting the ways in which science is featured in national curricula and syllabi and the manner in which it is taught to primary-grade learners. Lessons can be learned from these efforts and aligned with broader systemic reforms to ensure that primary science is incorporated into overall planning and resourcing for foundational skills development. These efforts can also be aligned with commitments through the global Greening Education Partnership, which focuses specifically on greening education to respond to climate change, including indicators for climate change education through the Monitoring and Evaluating Climate Communication and Education (MECCE) Project.

STEP 3:

A set of concrete steps for achieving the called-for systemic changes

Countries that adopt primary science as the final element in a robust foundational skills package and their development partners should agree on the process for system adaptation that addresses the concerns about training, resourcing, and monitoring identified above. The specifics of each step may differ depending on context, and the actual design and implementation at the country level should be locally led, but the essential elements needed to incorporate science into a country's foundational skills framework should be broadly concretized and endorsed by those most likely to engage in collaboratively planning the necessary financing. Teacher preparation and training, continuous professional development programming, materials development, and monitoring and evaluation systems for science programming must parallel similar efforts in literacy and numeracy, to generate a fuller and more robust portrait of skills development in the primary grades. Particular attention should be paid to teacher preparation to reinforce knowledge and practice, and to intentional planning to develop and use low- and no-cost materials for early inquiry, as a bulwark against the otherwise potentially high cost of additional teaching and learning resources.

Figure 5: Four Pillars of Science Education



Locally Led Primary Science Education and Climate Adaptation

At the local level, integration of inquiry-based primary science as part of a foundational skills approach will need to address all elements of the local educational ecosystem. Learner learning depends on a system of supports that, when aligned and working together, builds teacher capacity, provides resources for learners and educators, engages families and communities to support learning, and ensures that policies and systems are coherent and evidence based. To improve learner achievement in science, as in any other subject, each of these system components plays a critical role. Attention to climate science, as a grounding and activating factor for system change, should be woven across all elements of the system.

A locally led, sustainable, and foundational science program should address the following factors within each system element.

Teacher Capacity for Foundational Primary Science

Ensure Teacher Understanding of Science Concepts and Practices

Teachers must have knowledge and understanding of the concepts and practices of science and how to teach them. To do so, teachers and their supervisors need comprehensive, sustained professional development to build their understanding of science and their ability to base their own instruction on evidence-based, child-centered practices.

Ensure Systemwide Alignment of Science Concepts and Practices

Teacher education must include pedagogies and practices that support knowledge and understanding of the concepts and practices of science and how to teach them through inquiry.

Strengthen Teachers' Science Language Skills

The language of science is rich and complex. Teaching and learning science creates opportunities for developing language skills—both written and verbal—at the earliest stages. Teachers whose own abilities to communicate scientific ideas verbally and in writing have a more solid foundation from which to instruct others.

Clarify Teachers' Visions of Effective Practices

Teachers need images of what good, evidence-based practice looks like in contexts similar to the ones in which they work. Most teachers and their supervisors have never seen or experienced many of the child-centered, inquiry-based instructional practices supported by research, and so demonstrations and simulations must be part of professional development.

Support Varied Modes of Instruction

While the center of science learning continues to be learners' active engagement with the work and ideas of science, learning through direct instruction, reading science texts, writing and drawing, and discourse and debate are also important instructional tools when used appropriately.

Emphasize Meaning-Making

The overall goal of foundational science is to enable learners to become enthusiastic and purposeful scientific thinkers and lifelong learners with critical-thinking and problem-solving competencies. Core science instructional practices should provide opportunities for learners to do authentic scientific work so that they can go on to identify problems in their communities and beyond and work collaboratively to explore and enact solutions.

Resources for Foundational Primary Science Learning

Ensure Sufficient and Appropriate Teacher and Learner Resources

Teachers need grade-specific resource packages, which include a curriculum that describes the scope and sequence for introducing science concepts and practices, guidance in how to structure individual lessons, instructional resources for implementing the lessons, and simple assessment tools for measuring learner progress. The absence of commercial science materials for primary schools in LMICs is an opportunity to develop national or regional science materials that reflect learners' lives; are topical, gender sensitive, and ethnically diverse; and are grounded in the naturally occurring earth, biology, physics, and chemistry of a particular area.

Build Teacher Support Structures and Communities of Practice

Teachers benefit from regular access to coaches and mentors who understand and have experience with the new instructional approach and to a peer network of teachers who work together to strengthen their practice. Teacher communities of practice can provide both social support and problem-solving to help teachers overcome barriers with localized, adapted solutions.

Bringing Families and Communities into Foundational Primary Science

Engage and Respond to Communities and Families

Learners are more motivated to investigate scientific questions when they feel part of a culture of science, including families and their children. Direct links and structured ongoing communication between the classroom, the family, and the community ensure success in science and lead to stronger advocacy for improved science instruction. Foundational science programming, particularly when focused on climate change response and adaptation, can give families and communities tools to engage in science activities at home and in the community and to monitor and track science progress. Links between science activities and health, nutrition, and workforce and economic development are explored and supported to build out foundational science benefits across communities.

Support Local Language Science Learning

As literacy instruction has changed in many LMICs, young children increasingly begin primary school learning in the local language, which provides an additional link to community practices, norms, and resources and allows science instruction to flow from the lived and understood experiences of learners. When science is introduced in the early grades, children develop a working vocabulary for scientific terms in their own language. Concepts and language and the comfort derived from practicing early science serve to build a strong foundation. Once children move on to national language instruction, they no longer have to build new conceptual frameworks.

Foundational Primary Science Systems and Policies

Agree on Performance Standards

All levels of the education system must share a common vision of effective instruction, articulated in the form of learner and teacher performance standards. Standards provide all stakeholders with a common understanding of the skills and competencies that learners need to develop to become autonomous science thinkers. Standards also help teachers and supervisors ensure that effective instructional practices are used. Links should also be built with content and standards of pre-service training programs to establish a strong basis for science as teachers enter the system, and with meaningful, contextualized assessments of science skills and habits of mind.

Use Data to Support Continued Improvement

All levels of the education system must share common tools for measuring and reporting learner progress and teacher change. Families and communities must be able to understand and respond to presentations of these data. A shared vision will lead to change only if that change is measured and reported in ways that are clearly understood by all involved. Assessment and evaluation tools should reference the common teacher and learner performance standards and indicators, and provide educators with useful information to guide their instructional planning and classroom management. Assessments should focus on science practices as well as on science knowledge and be authentically designed and inclusive of locally relevant content. Likewise, tools that track activities, monitor fidelity of implementation, and capture demographic data will make linkages between what is being implemented, how it is being implemented, individuals and groups receiving the intervention, and outcomes. These data enable a more holistic analysis of effect on educator and learner changes.

Emphasize the Connections between Science and Other Core Subjects

The importance of science as a foundational skill must be made explicit, and connections between science and other core subjects must be amplified. The practices and concepts of science are relevant across the core subjects, and learners' deep understanding is enhanced when those connections are made explicit.

Center Climate Change and Climate Science in Primary Science Curriculum and Instruction

Climate content and activities are easily integrated into existing programs of study, and inquiry-based activities related to climate science can be done at little cost and with learners of all ages and capabilities. Centering climate change within a primary science program allows it to be immediately relevant to learners' lives, as they connect learning to their personal experiences. It also provides an anchor for action and engagement in the school and community, a window into possible future careers, and opportunities for citizen-led science with a practical purpose.

> "Learning science involves learning a system of thought, discourse, and practice—all in an interconnected and social context—to accomplish the goal of working with and understanding scientific ideas."[27]

27 National Research Council, 2012, p. 252

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To get people to be decent in this world, they have to have some kind of intellectual training that involves… observation, evidence, and basis for belief.”

—Jerrold Zacharias, EDC founder, on the importance of science education

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